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BIRTH OF A PROFESSION: FOUR DECADES OF MILITARY COST ANALYSIS

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BIRTH OF A PROFESSION: FOUR DECADES OF MILITARY COST ANALYSIS

The need for estimating resource requirements has been around for thousands of years, but the development of cost analysis as a specialized body of knowledge did not begin until after World War II. Much has happened since then, and it is time to take stock of where we have been as we prepare to move ahead into the nineties. This paper traces the progress and growth of cost analysis as a discipline from the 1950s to the present; first as a qualitative history, and second from a quantitative standpoint. Because of the numerous and diverse elements of cost analysis, this was no small task. The many threads running through our professional history include the roles of distinguished analysts, the development of specific methodologies, and a changing institutional structure. Rather than focus on a specific thread, I attempt to weave a coarse blanket which identifies the prominent contributions and interrelationships leading to the many facets of cost analysis as we know it today. In particular, I try to demonstrate how the introduction of new concepts and changes in the role of cost analysis was often a result of political influences, changing economic fortunes, and personalities, both inside and outside the Department of Defense. Under no pretext is this paper presented as a comprehensive history of military cost analysis. Indeed, the definitive history has not yet been written. Moreover, much of the history is contentious, as major actors who participated in the development of the profession have opposing interpretations of the same events. As a result, the reader will find a mixed and, depending on the source, perhaps somewhat biased coverage of topics beginning with the role of cost analysis in long range planning and ending with a focus on cost estimating in the military acquisition communities.¹ The story that emerges reveals the growing importance of a profession in the evolving context of major weapons procurement. Over the last four

¹Any errors in historical fact or interpretation are, of course, the author's own.

decades, military autonomy in acquisition, among other areas, has eroded. The defense budget has been subject to far greater scrutiny due to competition between the services and between the Department of Defense and other national priorities. How these forces led to the growing importance of cost considerations in decisionmaking is the subject of this paper.

The Fifties--Our Formative Years

Many of the key techniques of cost analysis were around long before the 1950s. Perhaps the most prominent was T. P. Wright's theory of the learning curve first published in the February 1936 issue of the *Journal of Aeronautical Sciences*. At about the same time, economists were formulating concepts of cost such as opportunity costs and fixed and variable costs, as well as developing and applying cost functions to describe some aspects of production. Other elements of costing were also being formulated by pricing analysts negotiating major contracts for the government in World Wars I and II. However, accurate and reasonable pricing took a back seat to procuring needed weapons during major conflicts. Moreover, the rapid disarmament of America following every war prior to WW II provided no peacetime incentive for the development of a military cost estimating capability.

As our nation entered the fifties with its new role as a world superpower, it felt the requirement to maintain a strong defense, increase social spending, and balance the budget after years of war-induced debt. Moreover, President Eisenhower, considered by some to be excessively frugal with the national budget, believed that our country's strength lay in its economy. To Eisenhower, large defense budgets could eventually damage the growth of the economy and, in turn, our long-run national interests. The cost of weapons became a primary consideration.

Cost analysis was not a profession in the 1950s, even though various forms of the discipline were being developed and practiced by pricing analysts, statisticians, operations researchers, management analysts, and economists. One form of cost analysis, that practiced within the context of military weapon systems, was just emerging at this

time. The work going on in acquisition agencies, headquarters, research centers, and other military locations was so new and specialized that it would take decades before a unified body of thought would emerge. However, the most basic concepts of weapon systems cost analysis can be traced to the fifties.

Perhaps the most significant contributions to weapon systems cost analysis were made by analysts of the newly formed RAND Corporation who led the way in codifying the emerging profession in the literature. In 1948, the Air Force founded the RAND Corporation (established as Project RAND by the Army Air Corps in 1946) to maintain the scientific expertise developed in WW II, and to conduct independent and objective national security research. One element of their research was systems analysis, pioneered by Ed Paxson, a RAND mathematician. The new technique of systems analysis was actually based on operations research. Fred Kaplan described Paxson's role this way:

At RAND, Paxson invented the term 'systems analysis.' It differed from the 'operational research' of World War II in one critical aspect. An operational researcher answered the question: What is the best that can be done, given the following equipment having the following characteristics? The systems analyst, as Paxson conceived of the notion, would answer a more creative question: Here is the mission that some weapon must accomplish--what kind of equipment, having what sorts of characteristics, would be best for the job? [1, pp. 86-87].

In dealing with decisions on development and force composition, systems analysis was more future oriented and broader in outlook than was operations research. This concern with the future vastly increased the number of variables and uncertainty when analyzing proposed weapons to achieve a given task. Nor was mission effectiveness the only priority. Anticipated dollar cost was soon introduced as a proxy for the real (i.e., opportunity) costs of obtaining competing systems. Consequently, the basic systems analysis question of which weapon system is best for the job became, given a fixed budget, which weapon system is most cost effective. The corollary of the fixed budget question was: Given a



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fixed level of effectiveness, which system can do the job more cheaply? Cost-effectiveness analysis, an approach with a different focus than systems analysis, was born. Although the terms are often used synonymously in some literature, the differences are crucial. The emphasis in systems analysis is structuring the problem, and within this construct one examines relative measures of merit (principally cost) for numerous alternative solutions. However, the cost analysis cannot take place until the conflict scenario or system for examining the problem is first established. The cost-effectiveness analysis is similar to a cost-benefit analysis, but in the case of military applications, the expected effectiveness of a weapon system substitutes for benefits which are often more easily measured in dollars for civil applications. With the introduction of cost-effectiveness criteria to systems analysis, the Department of Defense now had the ability to rationally analyze, group, and decide among alternatives in a world of scarcity.

In the first analysis incorporating a cost comparison (between a proposed turbo-prop bomber and the then-future B-52), RAND relied on Air Force cost figures to conclude that the turbo-prop was the dominant bomber. When the results were briefed to the Air Staff in November 1949, General Curtis LeMay, Commander of the new Strategic Air Command, disputed the cost figures and requested another meeting the following month. Subsequently, the estimating ground rules were changed without RAND's knowledge. At the next meeting, RAND learned that "the cost of the turbo-prop bomber had doubled, and the cost of the pure jet had gone down 50 percent" [2, pp. 1-2]. Although this was a simple misunderstanding, some participants felt that RAND had been intentionally deceived. Accordingly, RAND vowed to develop their own cost estimating capabilities. One of the benefits of an independent cost analysis capability would be the freedom to move toward weapon system costing, in contrast to the services which tended to focus on hardware only. Thus, in February 1950, the Cost Analysis Department was established at RAND.

An intellectual dialogue between RAND's Economics and Cost Analysis Departments led to important concepts still in use today. Some of the methodologies and concepts that RAND pioneered in the fifties are as

follows:

- Parametric cost estimating
- Incremental (marginal) costing
- Identification of cost elements
- Weapon systems cost concept
- Total force structure cost analysis
- Program Planning and Budgeting System (PPBS)

Through the application of specific cost analysis tools in a matrix of cost elements, RAND was able to fully estimate the cost of individual weapon systems. However, the costing of combinations of systems, or force mixes, represented a major analytical breakthrough. The analysis of total force structure costs allows comparison between competing systems and/or determination of the marginal costs associated with projected force structures. By dealing with the larger force structure, the analyst eliminates some of the lower level sub-optimization problems that occur when dealing with individual systems in isolation. Total force cost analysis also contributed to program budgeting. In order to accurately determine the incremental costs of adding a system to the existing (and otherwise fixed) force structure, it was necessary to accurately categorize and time-phase the investment and operating costs. Total force structure cost analysis required programmed cost estimates for each fiscal year in a manner which foreshadowed the well-known PPBS system installed in DoD.

The development of a strong costing capability gave RAND the unique ability to provide decisionmakers information on the cost effectiveness of proposed new systems in a long-range planning context. Operations researchers at Stanford Research Institute, John Hopkins University, and in industry (mostly Lockheed) also contributed during this time, but the bulk of the work was at RAND. Cost analysis was a crucial half of the cost-effectiveness equation, although emphasis was more on determining the relative cost of alternatives instead of detailed estimating. Some of the more prominent names were Gene Fisher, Harold Asher, Milton Margolis,

and, of course, David Novick. Novick would later gain the reputation as the "father of cost analysis."

At the time RAND and other defense intellectuals were postulating the initial tenants of cost analysis, there was little capability for cost analysis or related techniques of cost estimating within the government. Defense firms had developed the industrial engineering approach to cost estimating (also known as engineering buildup, grass-roots, and bottom-up method). However, competition and proprietary data limited the spread of this knowledge. Within DoD, cost analysis was largely the province of a select group of pricing analysts who were responsible for "review and consideration" of cost estimates submitted by defense contractors [3, p 93]. Pricing analysts used analogy with similar systems as a test of reasonableness, an early form of parametrics. In fact, the role of cost analysis was much more narrow than it is today. According to a senior economist in the Office of Procurement and Production, Air Material Command, cost analysis was:

...the technique of evaluating specific elements of cost or price to determine whether the cost of any element can be influenced by closer pricing. The aim of this approach is not to control profits, but to effect cost control and cost reductions [3, p 187].

Pricing analysts were so specialized and few in number that it wasn't until September 1958 that a pricing office was formed in the Air Force Aeronautical Systems Center. In July 1959, the function was centralized into a pricing division manned by 17 analysts. At the time, the division analyst was "the expert in cost estimating" [4, pp. 18-22]. Unfortunately, the analysts in the acquisition centers of each service focused their attention on acquisition costs, which were viewed as more important than operations costs. However, the resource impact of operational decisions was important in the field. To facilitate financial planning, statistical services divisions and management analysts were responsible for the development and maintenance of cost factors for construction, personnel, and other operating expenses [5].

Although RAND had already demonstrated the importance of cradle-to-grave costing, a perceived split between acquisition and operations cost analysis was already forming in DoD. For many reasons, analysts in the acquisition commands accorded lower emphasis to operating and support costs. Moreover, the acquisition analysts developed more technical skills and expertise than their counterparts in the operating commands. Events in the sixties would further emphasize this split as acquisition issues moved into the forefront and dramatically raised the visibility of cost-effectiveness analysis. As a result, DoD would be forced to develop a much larger and more competent estimating capability.

The Sixties--Growth and Disenchantment

The role of cost analysis in defense took center stage when Defense Secretary Robert McNamara and his 'whiz kids' came to power in 1961. Secretary McNamara, an operations analyst himself, brought in Charles Hitch, a Rhodes scholar from The RAND Corporation, as his comptroller. Hitch, co-author of *The Economics of Defense in the Nuclear Age*, had been conducting systems analysis for a decade at RAND. This technique introduced rational thinking to a world of uncertainties and Hitch firmly believed in its power. So he established a new comptroller office, the Deputy Assistant Secretary for Systems Analysis, and asked Alain Enthoven, another RAND analyst, to head it. Enthoven's office moved quickly to apply these methods to evaluate military programs, and the Pentagon soon learned about the importance of cost-effectiveness analysis.

The new financial environment of the sixties could best be described as a period of rational and more centralized decisionmaking under constrained budgets. The cost of weapon systems became paramount as the nation attempted to fight the Vietnam War without impacting the overall economy. The key to McNamara's approach to decisionmaking was a new method of analyzing service budgets. Prior to McNamara's time, information was not collected on the cost of programs. Instead, budgets were submitted by input-oriented resource categories such as pay, O&M,

R&D, etc., without any relation to mission.

David Novick, who saw the importance of an output-oriented program structure for cost analysis, had been pushing program budgeting as early as 1952 without success. However, Novick, along with Gene Fisher, presented their ideas to McNamara while he was still CEO at Ford. McNamara was keenly interested in applying this form of budgeting to Ford's commercial business, and when he was selected to head the Office of the Secretary of Defense, he remembered that the work on program budgeting had been done within RAND's Economics Department under Hitch. Soon after Hitch became DoD Comptroller, PPBS was instituted (in 1961). With an output-oriented budgeting system partially implemented, the new Office of Systems Analysis went to work examining proposed weapon systems in a systematic, rational manner. The era of centralized decisionmaking was beginning.

These were hard times for the Air Force, as key projects such as the Skybolt and B-70 and other programs were terminated because studies by OSD's Systems Analysis Office determined that other weapons could do the same job more cheaply, and the Minuteman missile procurement was reduced from 3000 to 1000 [1, pp. 254-255]. The Air Force, winner of the budget wars in the fifties as sole wielder of our nuclear deterrent, had also recently lost a share of the budget to the Navy's new nuclear-armed Polaris submarine. They were, therefore, particularly disgruntled about losing highly desirable weapons due to what was viewed as OSD's unhealthy dependence on systems analysis. But as the years passed the Army would also lose prized programs such as the Nike antiballistic missile program, while the Navy found themselves unable to get new escort ships for a long time. Thus, it was ironic that the seeds of discontent with cost analysis were sown at the very time the field was approaching its zenith (in terms of influence on defense force structure).

Not only did the Polaris end the Air Force dominance in nuclear weapons, it ushered in a new form of contract management. Because the submarine was so complex, the Navy hired Booz, Allen and Hamilton to develop an information system to monitor and control cost and schedule. The result was the Program Evaluation and Review Technique (PERT). The

Air Force was using a similar technique called the Program Evaluation Procedure (PEP), but by the early sixties, PERT and its cost control derivative, PERT/COST, became the dominant project management system. The concepts of a work breakdown structure and work packages are owed to PERT and PERT/COST. Unfortunately, this system was not always compatible with planning and control systems already in place at the contractor's firm. The result was often a dual set of books, one to satisfy the government and another for internal company requirements. The new Air Force Systems Command took on the task of standardization in 1964 as part of their ongoing Cost Management Improvement Program, and by 1966 the Cost/Schedule Planning and Control System (C/SPCS) was established in AFSC Manual 70-5, Annex 4 [6, p 9]. This system was not really a system, but actually a set of specifications that the contractor's own system had to meet. Although the criteria have evolved since first standardized in DoD Instruction 7000.2 (1967), they have stood the test of time.

The McNamara-Hitch-Enthoven era was a period of rapid growth in DoD financial management systems. The establishment of PPBS, Cost Information Reports (on major contracts), and Cost/Schedule Control Systems Criteria (C/SCSC) along with the high level review of a program's cost effectiveness found the services wanting for their own highly trained cost analysts. Thus, the development of an internal DoD costing capability can easily be traced to the sixties. Because of the unprecedented spotlight that systems analysis directed to high profile programs, the Air Force decided in September 1961 to begin teaching cost analysis at the Air Force Institute of Technology (AFIT). Not surprisingly, RAND cost analysts prepared the initial course material in a series of lectures. By 1964, AFIT would be designated as the executive agent for all DoD cost training. However, as late as 1965, OSD Comptroller Hitch declared that "an effective cost estimating ability does not exist within the Department of Defense" [7, p 4]. In particular, Hitch highlighted the lack of adequate data, the insufficient number of competent analysts, and the military's view that an independent cost estimating capability was not necessary. Criticism of DoD cost estimating throughout the sixties served to increase cost

authorizations in each service and to underline the need for professional training. But criticism of OSD cost effectiveness would see the role of cost analysis dramatically altered in the next decade.

By 1965, the impact of cost-effectiveness analysis was even more pronounced. When Dr. Robert Anthony of the Harvard Business School replaced Secretary Hitch as DoD Comptroller, former RAND analyst Enthoven became his own man. Systems Analysis, formerly an office within OSD Comptroller, had been raised to the level of Assistant Secretary of Defense. The new office also expanded to four general divisions including one for cost analysis and one for economic studies [8, p 76]. Dr. Harold Asher, who had published *Cost Quantity Relationships in the Airframe Industry* at RAND in 1956, was selected to head the costing division. By comparing levels of predicted effectiveness to estimated resources, the systems analysts would determine at what point additional weapons would result in diminishing marginal returns for achieving a given mission. Cost analysis had gained a primary role in the examination of alternative force structures at the OSD level.

In retrospect, the services were not adequately prepared to present or defend their programs to OSD in the early days of systems analysis. Up to that point, individual services had few cost analysts, many weapon systems were not viewed in the broader context of DoD objectives, and guidelines establishing future financial resources were widely ignored. Moreover, the McNamara administration forced weapons on the military like the M-16 rifle and F-4 aircraft (it was the Air Force which resisted adapting the Navy F-4) that turned out to be quite effective. Other decisions were not so cost effective. With the intent of saving vast sums of money (and under intense pressure from President Johnson), McNamara selected the TFX (F-111) to fulfill Navy requirements for fleet air defense and Air Force needs for a tactical fighter-bomber. Neither service wanted a common aircraft and the Air Force was especially riled when the Secretary overruled its source selection board, choosing General Dynamics instead of Boeing as the principal contractor. For many years, the F-111 would prove to be neither cheap nor effective. Such battles would serve to increase the ranks of those who felt systems analysis had

gone too far.

By the mid- to late-sixties, the grumblings against systems analysis had grown to a dull roar. Generals and Admirals thought that their experience and decisionmaking authority had been usurped. The centralization of decisionmaking authority at OSD resulted in a proliferation of management systems and the perception of intolerable levels of paperwork. Lieutenant General Ira C. Eaker, USAF (Retired) was one of the first to speak out in 1965:

One of the prime obstacles to adequate defense weapons... has been a hurdle called cost effectiveness. This test applied by scientists and theorists has killed off many new weapons, urgently requested by military leaders [9, p 17].

By 1967, criticism was rampant and some members of the defense establishment eagerly awaited the end of President Johnson's administration. Systems analysis was a wonderful tool for long range planning in peacetime, but many felt that the cost criterion was too stringently adhered to in a time of war. As the Vietnam war intensified, military leaders fought more vigorously against continual study which they believed would stifle innovation. The term "paralysis by analysis" was coined in this era. Assistant Secretary Enthoven found himself under frequent attack and having to defend against the perception that "In systems analysis, high-speed electronic computers operated by crew-cut young 'Whiz Kids' are making major defense decisions" [8, p 75]. In August 1967, the editor of *Armed Forces Management*, C. W. Borklund, published a four-part series on "Cost-Effectiveness vs. Creativity." The military had become increasingly concerned that decisions made in the sixties would jeopardize our defense posture in the next decade. Finally, Vice Admiral Rickover, disgusted over the decision to make the carrier *John F. Kennedy* conventionally powered, and with cutbacks in building nuclear submarines, hammered analysts whom he perceived had placed budget considerations over the value of human life.

...decisions appear to be made by the rules that are ground out by the cost-effectiveness analysts. It was never the intent of the Defense Unification Act that a group of analysts would, in effect, become the decisionmaking apparatus of our Defense Establishment.

Just what are the qualifications of the cost analysts? Their experience? Their accomplishments? Their reputations?

The only record of accomplishment of these social scientists is reducing budgets [10, pp. 28-29].

Much of the problem with systems analysis was that while estimating the cost of systems was difficult enough, determining effectiveness was even harder. As early as 1957, RAND had published *Ten Common Pitfalls* of systems analysis (RM-1937) and E. S. Quade had a chapter on the same topic in his 1964 book, *Analysis for Military Decisions*. So it was not surprising when RAND economist James R. Schlesinger warned Congress in 1968 of the many limitations of economic analysis in national security issues and of the contradictions between political decisionmaking and good analysis [11, p. 436-437]. Thus, shortly after Melvin Laird took over as Secretary of Defense in 1969, he de-emphasized the formal role of systems analysis and returned the decisionmaking authority to the service secretaries under OSD guidance.

Although systems analysis had been reeled in, there was still a strong demand for cost analysts. Congress had grown accustomed to detailed reports on new weapon systems, and was often perturbed with unreliable cost estimates from the services. In fact, Senator Proxmire's enthusiasm for PPBS and economic analysis led to the publication of DoD Instruction 7041.3 in 1969 to institutionalize many cost techniques--from discounting to regression analysis. Altogether, the new instruction recommended 21 techniques of economic analysis (the new buzz word to replace systems analysis) that the services should consider for "solving problems of choice" [12, p 61].

Unfortunately, the increasing complexity of weapon systems made economic forecasting more difficult. In addition, inflation which had not been a problem in the fifties and early- to mid-sixties was now a

factor in economic forecasts. Not all of the military problems could be blamed on inflation, however. The real difficulty lay in getting Congress, with its short-term political outlook, to understand the full costs of military R&D. The services and industry had never been successful in accomplishing this end, resulting in a variety of strategies which did not fully reflect true development costs. Industry tended to buy in at the beginning, expecting to recoup losses in lucrative, sole-source production contracts. Cost growth was the final product, but its appearance usually came to light only after a program had developed a strong constituency. Although the services had been wrestling with cost growth for over two decades, the extent of the problem did not become a public issue until Ernest A. Fitzgerald, Deputy for Management Systems in the office of the Assistant Secretary of the Air Force for Financial Management, blew the whistle on massive overruns and degraded technical performance on the Lockheed C-5A airlifter [13]. The C-5A had been touted as the "Miracle of Procurement" under the Total Package Procurement scheme in which development and production were funded in one contract. The uncertainties of technological development and the need to work within a fluent political structure led to the failure of Total Package Procurement. But the resulting public attention led to renewed demands for political accountability which directly affected the cost analysis profession.

Problems with the C-5A led to numerous studies on the causes of cost growth in weapons procurement. Although some people judge defense acquisition by the amount actual costs exceed the original estimate, the more correct method is to exclude inflation and quantity effects from any calculation of cost growth. Thus, cost growth equals the current estimate, in base-year dollars and normalized for quantity change, divided by the development estimate. The development estimate is favored over earlier planning estimates because by this point the system definition is of sufficient detail for more credible estimating. Cost growth then results from poor estimating, production stretchouts, configuration changes, funding constraints, mismanagement, and numerous other factors--many outside the control of the program manager. In most cases, the sum

of these effects is often insignificant compared to the cost of inflation and quantity increases. But at the time the C-5A made headlines, inflation was only just becoming a problem, and a formal cost reporting system to Congress was not in place. Perceptions on cost growth were then formed by rough comparison of successive yearly budgets for a given program.

By 1969, Congress was fed up. Testimony by new Defense Comptroller, Robert Moot, revealed cost growth totaling \$19.9 billion in 27 of 35 major weapon systems reviewed (the original estimate for the 35 systems was \$74.24 billion, yielding an average cost growth of 26.8 percent). He attributed half of the problem to faulty estimates. The furor over spiraling costs led Congress to cut \$3.8 billion out of the FY70 appropriation for hardware procurement and RDT&E, and to label 1969 as the "Year of the Cost Overrun" [14, pp. 16-17]. The services' reaction to the national clamoring over procurement practices, waste, and excessive costs would serve to greatly improve cost estimating in the seventies.

The Seventies--A Changing Role

The shifting emphasis away from systems analysis and the uproar over cost growth permanently changed the role of cost analysis. Where previously cost analysis played a major role in long range planning for analysis of potential weapon systems, now it would be more important to determine the resource requirements of a proposed weapon system. This change in emphasis from planning to programming to budgeting signaled an urgent requirement for more accurate costing. Only rough but consistent estimates were necessary to compare proposed weapons. But estimating precise costs to please Congress was another matter. Unfortunately, the military capability for in-depth cost analysis was still very limited. Industry leader M. D. Sprague noted that "DoD doesn't have the means to estimate costs adequately at the present" [15, p 45]. Furthermore, the Department of Defense agreed that inability to properly estimate costs allowed contractors to get away with low estimates. Cost management techniques such as *should* cost, design to cost,

and life cycle cost would gain increasing attention. From now on, cost analysis would be seen as integrally tied to procurement reform and regulation.

Secretary Laird was serious about improving military cost analysis as one way to reform the poorly regarded procurement system. His selection of well-known industrialist David Packard as Deputy Secretary of Defense underscored his resolve to fix procurement ills. Mr. Packard responded to the challenge with a series of memoranda and speeches to significantly improve the procurement system and internal cost estimating capabilities (see Table 1).

As a result of these policy elements, the acquisition environment of the 1970s was "substantially different from that of the 1960s" [16,

Table 1

COST AND PROCUREMENT INITIATIVES UNDER SECDEF LAIRD

1. Establishment of Defense Systems Acquisition Review Council (now known as the Defense Acquisition Board).
2. Requirement for services to improve cost estimating.
3. Establishment of milestones for major programs and review prior to validation, full scale development and production phases.
4. Requirement for independent parametric cost estimates (IPCE) for new systems acquisitions.
5. Requirement for all major programs to prepare Selected Acquisition Reports (SARs) as the basis for quarterly reporting to Congress.
6. Revision of the Planning Programming Budgeting System to include fiscal guidance (known as Consolidated Guidance) for consideration in JCS planning.
7. Establishment of the Cost Analysis Improvement Group.
8. Elevating cost to a principal design parameter.

p vii]. The role of cost analysis in examining force structures had diminished, but it became an important part in attempting to ensure a more effective procurement system.

Congress became less tolerant of cost overruns, but service responses varied tremendously. The Air Force had the capability for independent estimates within its Systems Command as far back as the TFX (F-111), while the Navy essentially ignored the requirement for years. On the other hand, the Army took several actions in response to the Laird revolution in acquisition. They initiated Project ICE (Improved Cost Estimates) in 1970 to improve their cost estimating methodology. The Army Materiel Command (AMC) created 250 more personnel spaces to provide cost analysts to program managers who previously lacked this capability. Other AMC initiatives were to establish a cost data bank and to start tracking Selected Acquisition Report (SAR) cost data on their major weapon systems [17, pp. 19-26]. Today, cost analysts are generally assigned to all major programs, cost data banks are common (if not complete), and SAR data have been the subject of extensive research. Overall, military cost analysis has progressed tremendously since 1970.

In the space of a few years, the role of systems analysis, and cost analysis in particular, had been almost completely transformed. (See Appendix A for information on the further evolution of systems analysis.) In the McNamara era, systems analysts had served as the initiators of plans; but under Laird, the office underwent a key reversal in which analysts "reviewed the programs proposed by the military after the dollar ceilings have been levied" [18, p 39]. To signal the changed emphasis on systems analysis, the name was changed in 1972 to the Assistant Secretary for Program Analysis and Evaluation (PA&E). Nevertheless, the office still wielded great influence because the Deputy Assistant Secretary of Resource Analysis (PA&E) also chaired the Cost Analysis Improvement Group (CAIG). The CAIG's primary role is to evaluate program office and "independent" service cost estimates for the Defense Selected Acquisition Review Council (DSARC), now the DAB, but they made many other contributions as well. The CAIG, in essence, established a mini-DSARC process for cost analysis in

acquisition. And, together with PA&E, the CAIG would make contributions to cost methodology and policy that significantly enhanced cost analysis capabilities in all services.

One of the more important developments under Laird was the Design-to-Cost (DTC) concept instituted by DoD Directive 5000.1, *Acquisition of Major Defense Systems* (1971). The DTC concept evolved out of value engineering and cost-to-produce ideas discussed in the sixties. However, the new instruction decreed that cost was a parameter equal to performance in design. Recognition of the tradeoffs between cost and capability had been encouraged as early as 1964 in DoD Directive 3200.9, *Project Definition Phase*. Nevertheless, cost was normally a secondary consideration to system requirements. Since the majority of system costs are determined early in the design process, the DTC concept was a tremendous spur to the further development of parametric estimating which is widely recognized as the best technique early in the acquisition cycle. The advantage of DTC was the ability to identify tradeoffs between cost, performance, and schedule while a program was still in the conceptual phase. DTC, therefore, was essentially cost-sensitivity analysis re-packaged under another name. The practice was given further credence when DoD Directive 5000.28, *Design to Cost*, provided specific instructions for implementing the policy first stated in 5000.1. Several joint guides and pamphlets on DTC also emphasized the importance and practice of this cost control technique.

Ideally, an analyst employing DTC would analyze the effect of design changes on development, production, and operating costs with the aid of parametric models. Although these models allowed the analyst to easily vary performance characteristics, they were primarily designed to estimate system costs at a rough order of magnitude. In practice, therefore, it was easier to use the design-to-cost concept to ensure that military equipment was procured near the planned unit production cost (known as design-to-unit cost or DTUC). The design-to-unit cost concept ignored operating and maintenance (O&M) costs--the bulk of system costs. Proper application of design-to-cost procurement requires knowledge of costs "...from the cradle to grave in the life of a major weapon system" [19,

p 65]. Existing cost models for operating and support (O&S) costs were poor at best. The DoD cost community was just getting on its feet and did not have the ability to accurately estimate O&S costs. Neither did industry. Boeing CEO, T. Wilson, wrote about the data deficiency.

...there is a serious deficiency in our ability to work life cycle costs. Our work in O&M is for all practical purposes limited to specification compliance with reliability and maintainability requirements plus optimization of integrated logistics support and specified requirements [20, p 63].

Recognizing the importance of O&S as comprising the bulk of system costs led to the emergence of life cycle costing. In 1974, Deputy Secretary of Defense Clements chartered a task group on "Visibility and Management of Support Costs" to develop means for identifying O&S costs by weapon system [21, p 56]. By the late seventies, life cycle costing (LCC) was complementing DTC as a technique for balancing investment and ownership costs. Thus, both DTC and LCC are tradeoff tools. One shows the impact of design features on acquisition costs and the other on operating support costs. Although the methods overlap to a degree, and the literature often uses the terms interchangeably, the main point is that analysts were now concerned with total system costing.

Another tool of the sixties that did not gain acceptance until the seventies was *should cost*,² which had been strongly advocated by E. A. Fitzgerald. His background as an industrial engineer led him to believe that the Department of Defense should use accepted efficiency standards to negotiate tougher contracts, and to rely less on parametric estimating techniques which included past inefficiency and waste. In his words,

I was disappointed. All the recognized experts--the RAND Corporation, McNamara's Systems Analysis people, the Air Force estimators--were pushing for the use of all other approaches to estimating costs [13, p. 35].²

Although *should cost* is more concerned with cost control than cost

²While Fitzgerald implies that RAND endorses the use of parametric estimating for contract negotiation, the contrary is true. Nowhere in

analysis, it provides feedback on the quality of cost estimates, which are integral to cost analysis. Eventually *should* cost became a credible, if not widely practiced, tool of cost analysis, even though at the time of its inception it was often resisted for political reasons. Nevertheless, there was at least one successful *should* cost study performed during the sixties. By 1967, the engine program of McNamara's pet project, the F-111, was in serious disarray and costs were skyrocketing. Secretary McNamara ordered the Navy (lead service for buying the engines) to perform a *should* cost at Pratt & Whitney which resulted in a contract reduction of \$200 million formalized in 1968 [13, pp. 138-145].

Should cost finally gained a measure of acceptance in the more favorable cost control climate of the seventies. The Army, more than any other service, gave the method widespread application. Mr. Arthur Smith, Director of Army Cost Analysis, believed that parametric estimates based on a relatively small database, should not be used "as the basis for decisions in the latter stages of equipment procurement" [22, p 20]. To correct this problem, the Army policy was to conduct *should* cost studies on negotiated non-competitive procurements and on selected major contracts with the promise of savings or where rising costs were a concern. Having performed only two such studies in the sixties, they set up a *should* cost training course at the Army Logistics Management Center in 1971 to develop a cadre of qualified analysts. The success of the Army approach was later confirmed in a GAO survey. Between 1973 and 1979, the Army conducted 89 *should* cost studies compared to 37 by the Air Force and only 3 by the Navy [23, p 50]. The GAO concluded that the cost of these studies was approximately one percent of the savings generated [23]. The phenomenal return on investment supported the *should* cost approach to negotiation and ensured that this method would continue to be used, although as the exception rather than the rule.

the RAND literature is this practice recommended, nor does anyone at RAND espouse such views. Parametric estimating at RAND was developed to provide rough order-of-magnitude estimates of weapon systems costs.

All told, the seventies marked a radical departure from the way in which major procurements were handled in the sixties. The relationship with contractors had slowly become more hardline, with DoD expecting quality weapons at lower cost. In the new climate, cost analysts found themselves thrust into the center of acquisition decisionmaking. Whereas OSD cost-effectiveness analysis had been seen as an intrusion of "bean counters" into the sacred realm of operators, in-house cost analysts had now secured a recognized position in the programming arena. In the eighties, the pendulum would swing even further in this direction.

The Eighties-- Movement to Professionalism

By the beginning of the eighties, the services had developed a strong cost analysis capability in the acquisition communities. Cost analysis had also gained an important role at major commands and a lesser but growing role in the field. The basic methodologies pioneered at RAND in the fifties, implemented by OSD in the sixties, and fully adopted by the services in the seventies assured that cost analysis would remain a significant responsibility of military comptrollers. However, cost analysts in 1980 could not yet claim professional status. As 1990 draws near, the jigsaw puzzle that had characterized cost analysis was finally completed as the military established professional standards for education, training, and practice in cost analysis. In addition, a professional society was founded and each service formed a cost center to better collect data, conduct and monitor research, and assist analysts.

The establishment of the Institute of Cost Analysis (ICA) in 1981 was the most significant event of the decade. Although other professional societies were already in existence (most notably the National Estimating Society), their membership was largely comprised of industry analysts rather than government "costers." The ICA provided DoD cost analysts a forum for the exchange of ideas, and promoted a body of knowledge common to cost analysis. The influence of systems analysis, which had been pre-eminent in the sixties, was apparent when the newly

formed ICA defined cost analysis as "that portion of systems analysis dealing with the tasks of conceptual modeling, cost and output measurement, model estimation and testing, and evaluation of the costs of each alternative" [24, p 5].

If systems analysis provided a common body of knowledge, it wasn't too common to the many analysts who were introduced to their profession by the time-honored method of "baptism by fire." The need for a professional society was apparent to all analysts who had learned their craft largely from on-the-job training and perhaps one or two classes which qualified them as "experts" in the field. Very few had a grasp or understanding of the full body of expertise that had developed over the years. Colonel Richard Goven, one of the founders of the ICA, emphasized that major decisions must be based on the work of "professional" cost analysts:

In the thirty years since "the RAND corporation pioneered the development of cost analysis concepts and methods...; cost analysis techniques were greatly improved and became an integral part of the management and decisionmaking process in government and industry. However, when the 80s arrived, cost analyst qualification and estimating standards were almost non-existent. One only needed to occupy a designated position to be a cost analyst" [25, p 10].

The Air Force and the Institute of Cost Analysis set up three programs to improve the quality and image of analysts. The Air Force Institute of Technology (AFIT) initiated a cost analysis Master's Degree, the first of its kind in the nation. In conjunction with ICA, AFIT also offered a "Professional Designation in Cost Analysis and Price Analysis" for defense personnel who completed a series of four core and four elective courses. Finally, ICA set up an examination board to award the title of "Certified Cost Analyst" to all who met the qualifying criteria and passed the requisite examination [26]. These three programs offered cost analysts new avenues for formal education and a means of gaining the credentials that Admiral Rickover had once questioned.

The need for professional cost analysts was reinforced by several events in the eighties that would bring weapon systems acquisition to the forefront of public attention to a degree not seen since the late sixties. The new Reagan administration would attempt to reform the procurement process through a series of recommendations that came to be known as the "Carlucci initiatives" (after the Deputy Secretary of Defense who stated them in 1981). No less than 8 of the 32 initiatives directly or indirectly impacted the work of cost analysts. These initiatives, listed in Table 2, either directly call for more accurate cost estimates or involve policies related to program stability which would also impact on program cost analyses [27]. In short, these initiatives directly relate to an important acquisition management principle that major programs must have realistic costing, budgeting,

Table 2

CARLUCCI INITIATIVES IMPACTING COST ANALYSIS

- #3. Encourage extensive use of multiyear procurement based upon a case-by-case benefit/risk analysis.
- #6. Require the services to budget to most likely or expected costs, including predictable cost increases due to risk.
- #7. Services must use economic production rates.
- #11. Present more realistic cost estimates by increasing efforts to quantify risk and deal with uncertainty.
- #18. Review various methods and alternatives for budgeting more realistically for inflation.
- #19. Forecast business base of major defense firms to insure better cost estimates and lower cost to the government.
- #20. Improve source selection process with added emphasis on past performance, schedule realism, and cost credibility.
- #22. Provide greater incentive on design-to-cost goals by tying award fees to actual costs achieved in production.

and funding. When estimates are continually low, there is a perception that the services "buy-in" to Congress the same way that a contractor "buys-in" with a low bid. To be fair, the official service estimates may not be what some cost analysts projected. However, the estimator takes the blame. This implication of deceit places cost analysts in a defensive posture before Congress and the public. As the decade progressed, repeated media exposure of procurement fraud, waste, and abuse brought the entire acquisition community under attack. Carlucci's reforms, as all others before, failed to appreciably improve the procurement process in the public eye.

Interestingly, at the same time cost analysts came under fire, they found that the discipline had come to play an integral role in the defense decisionmaking process. The vital need for cost analysis was reinforced by relentless media exposure of highly visible weapon programs such as the Army DIVAD (Sgt. York), the spare parts overpricing issue, and most recently, the rapidly changing estimates on some of the nation's most technically advanced forces. In turn, the public attention on acquisition spurred countless studies of the defense procurement system, numerous Congressional hearings and legislation on the topic, the President's Private Sector Commission on Cost Control (the Grace Commission), and the President's Blue Ribbon Commission on Defense Management (Packard Commission). Finally, the fiscal environment turned topsy-turvy with the passage of the Gramm-Rudman-Hollings Deficit Reduction Act. The combined effect of the adverse media coverage, new congressional laws, and real decline in the defense budget was to complete the swing of the pendulum that had begun in the sixties. Where once an atmosphere of friendly cooperation had existed between DoD and industry, now an almost adversarial relationship had taken its place.

By the mid-eighties, as attention focused on the fishbowl world of procurement, cost analysts were once again expected to improve their product. Although the analysts were not the decisionmakers, their studies and estimates were integral to Congressional decisions, to DoD decisions at every major milestone, to contract negotiators, for determination of progress payments, for program evaluation, and ad

infinitum. Despite the many forms and uses of cost analysis, the measurement of success remains the amount of cost growth on a program (regardless of source). To enhance cost estimating abilities, conduct research, and improve cost management, the Army, Navy, and Air Force each formally established a professional cost center between 1985 and 1986.

If the methodological developments of the fifties formed the foundation for military cost analysis, then the establishment of individual service cost centers surely represents yet another step on the road to professionalism. Over time, cost estimators had demonstrated their improved skills through more defensible analysis and even possible reductions in weapon systems cost growth. A RAND study that reviewed three decades of major weapons programs found that dollar-weighted cost growth normalized for inflation and quantity had declined from almost 50 percent in the sixties to 20 percent in the seventies [28, p 9]. Certainly, contributing factors other than improved estimating were responsible (e.g., adequate funding and configuration change), but the level of professionalism that cost analysis had achieved was undeniable. It is too soon, however, to close the book on cost overruns. In fact, developments in the late eighties indicate a possible resurgence in cost growth. We are fully into a period of tight funding that threatens program stability and promises inefficient rate production. Indeed, at least one author attributes lower cost growth in the eighties to the large Reagan defense budgets. According to Thomas McNauger,

...the elimination of cost growth did not result from significant advances in the science of cost estimation. Rather, sharply rising procurement budgets confronted the services with incentives to overestimate rather than underestimate future costs....and this suggests that unless procurement spending increases at the unprecedented rates achieved during the early Reagan years, cost growth will quickly return to the defense planning process [29, p 142].

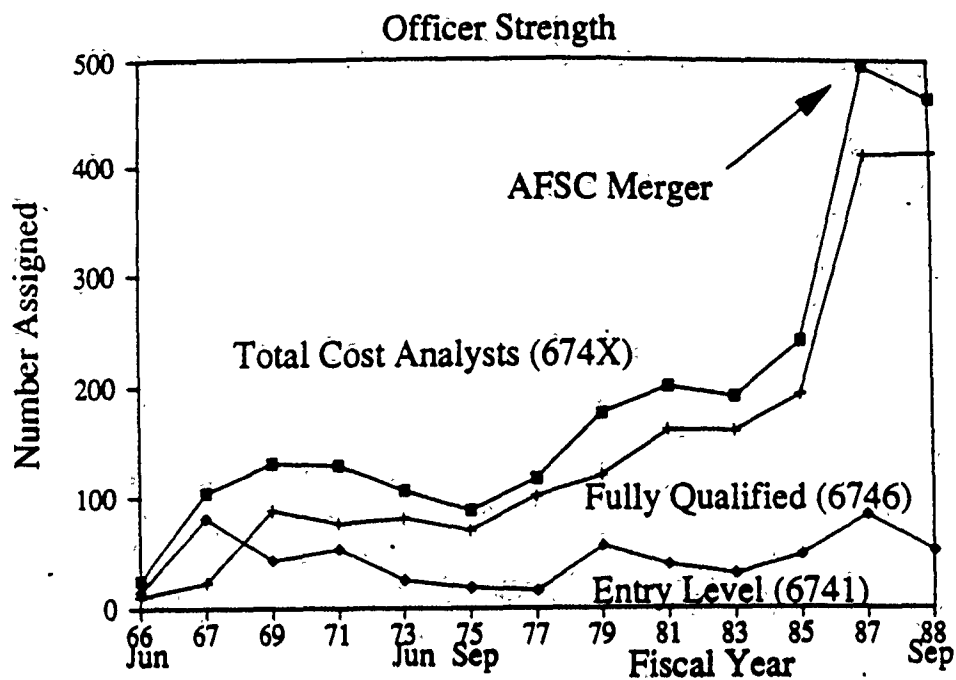
At the same time, DoD is talking affordability and competition while industry is worried about profitability and increasing risk. The increasing use of emerging and exotic technologies also suggests high

cost growth. It is not difficult to look to the future and see a number of major programs due to be fielded in the early- to mid-nineties that have the potential to vastly exceed their target costs if they are not already doing so. The expertise provided by the cost centers may turn out to be vital to recognizing and working on the solutions to such problems.

How Many Cost Analysts?

The preceding qualitative history demonstrates that the importance of cost analysis in the decisionmaking process, and the need for highly trained professional cost analysts, has increased dramatically. Growth in the numbers of analysts assigned to cost work is perhaps the best measure of this trend. As we shall see, the number of cost analysts employed in defense work has remained commensurate with the requirement. Within the defense community, cost analysts are employed by the government, by Federally Funded Research and Development Centers (FFRDCs), and by professional service companies and contractors. The number of cost analysts assigned or employed was available for each category with the exception of defense contractors. If these figures are representative of the whole (and there is no reason to believe otherwise), the overall trend is one of remarkable growth.

The personnel trend for the Air Force (Fig. 1) shows a steady climb from the inception of the cost analysis career field in FY66 through FY86, except for a dip at the end of the Vietnam War. The large spike in FY87 was due to the combining of the cost and management analysis career fields (see Fig. 2). Prior to the establishment of a separate cost analysis career field, management analysts had been performing this work at the headquarters level (and as statistical services officers before that). However, the many McNamara initiatives led to the requirement for a new class of professional cost analysts within the military. In general, cost analysts were found in the acquisition and logistics commands while the management analysts worked in the operating commands. Organizational control for both types of analysts rested in the Directorate of Management



Source: FY66 - FY69, Air Force Human Resources Laboratory
 FY71 - FY88, Defense Manpower Data Center

Fig. 1--Air Force Cost Analysts

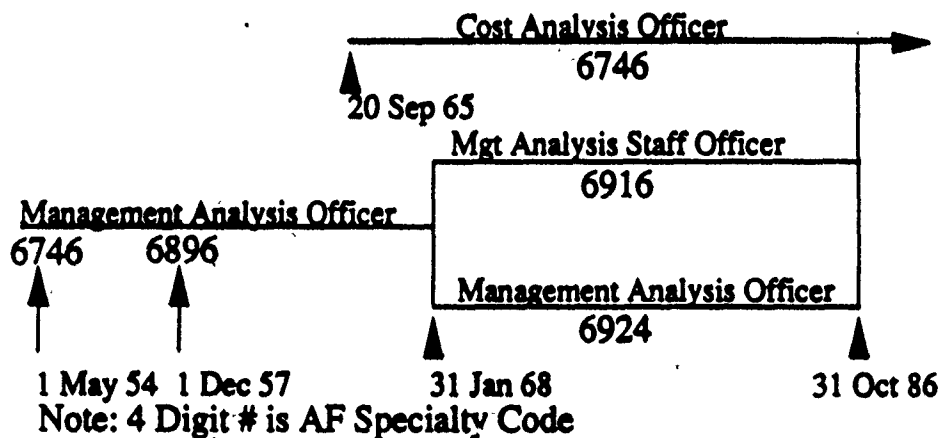


Fig. 2--History of AF Cost Analysis

Analysis which changed its name to the Directorate of Cost & Management Analysis (FY79) because of the growing importance of cost-related work. In FY86, the directorate became simply the Directorate of Cost, signifying the dominance of cost and data analysis over management and administrative-related work. In FY87, all management analysts became cost analysts with the expectation that more quantitative work and support costing would take place. Data on cost analysis strength for the other services was not available from the Defense Manpower Data Center because of different staffing policies. Whereas the Air Force trains cost analysts and assigns them to costing positions, the Army and Navy generally assign operations researchers to cost positions. Because not all operations researchers are cost analysts, tracking the numbers of officers in that specialty over time may not be representative of cost analysis alone. Nevertheless, it would be fair to state that the DoD experience is similar to that of the Air Force in direction and scope, due to greater Congressional interest in resources issues over the past several decades.

The upward trend in the number of Air Force cost analysts since the late seventies is mirrored by the FFRDCs (Fig. 3) that still maintain a cost analysis capability. A FFRDC is a nonprofit institution which offers the defense community a continuing relationship with an independent research organization. The RAND Corporation was the first FFRDC and, as previously noted, the first to establish a cost analysis group. Jim McCullough, of the Institute for Defense Analysis, examined military cost analysis in the seven FFRDCs with cost analysis groups (CAGs) between 1950 and 1975 [30]. His original analysis on staffing is the source of the data (interpolated from a graph) through 1975 in Fig. 3. Subsequent data came from senior cost analysts at each center. In large measure, the rapid growth of cost analysis in the early sixties was due to the need to implement McNamara's cost and budget initiatives. Because the services did not have organic capabilities, they turned to the research centers. Eventually, the services developed their own in-house cost expertise and the need for contracting out such work diminished. McCullough also attributes the decline to a Congressional backlash against think tanks in the early seventies, and to a change from

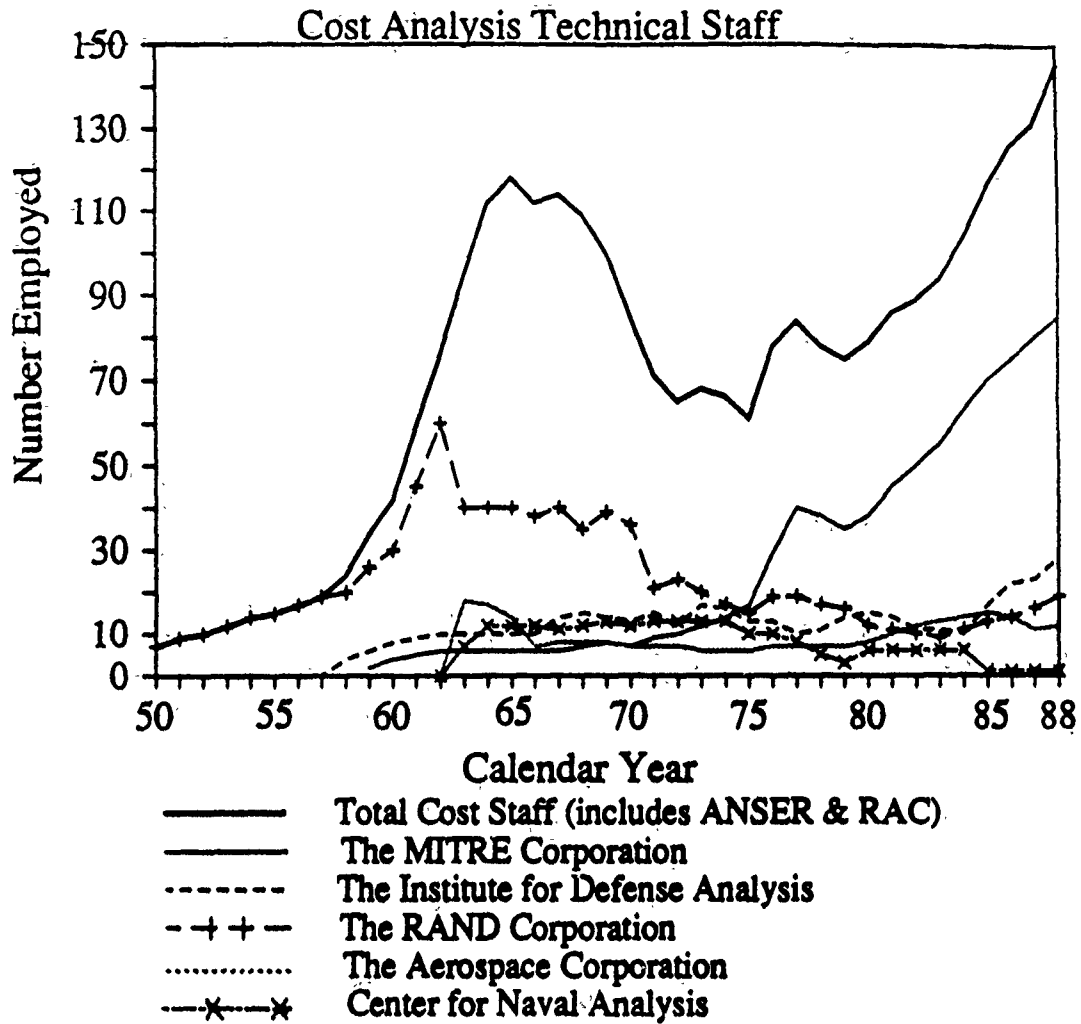


Fig. 3--Federally Funded R&D Centers

functional to project management within the centers [30, pp. 12-14]. Two of the FFRDCs no longer have cost staffs (ANSER and RAC went private). Of the remaining five FFRDCs with costing staffs, MITRE has experienced phenomenal growth, while IDA and RAND have shown recent, moderate growth. By contrast, CNA eliminated cost analysis as a formal function, although they retain a limited capability. Taken together, the remaining five FFRDCs have grown by over 100 percent since 1975, even exceeding the 1965 peak when there were seven centers with CAGs. This renewed emphasis reflects a continuing and expanding need for independent cost research. However, the FFRDCs face formidable competition from professional service companies that specialize in defense studies and analysis.

Several dozen commercial companies which specialize in defense work maintain staffs with cost expertise. This capability may fall under the rubric of cost analysis, economic analysis, and resource management. Of these firms, three companies are well known for their work in the cost field: Tecolote Research, Inc.; Management, Consulting, and Research, Inc.; and The Analytical Science Corporation. The phenomenal growth of cost analysis at these firms is perhaps not reflective of other service companies, but the direction is. Examination of Fig. 4 shows that the number of cost analysts grew at a fairly steady rate through 1983 when

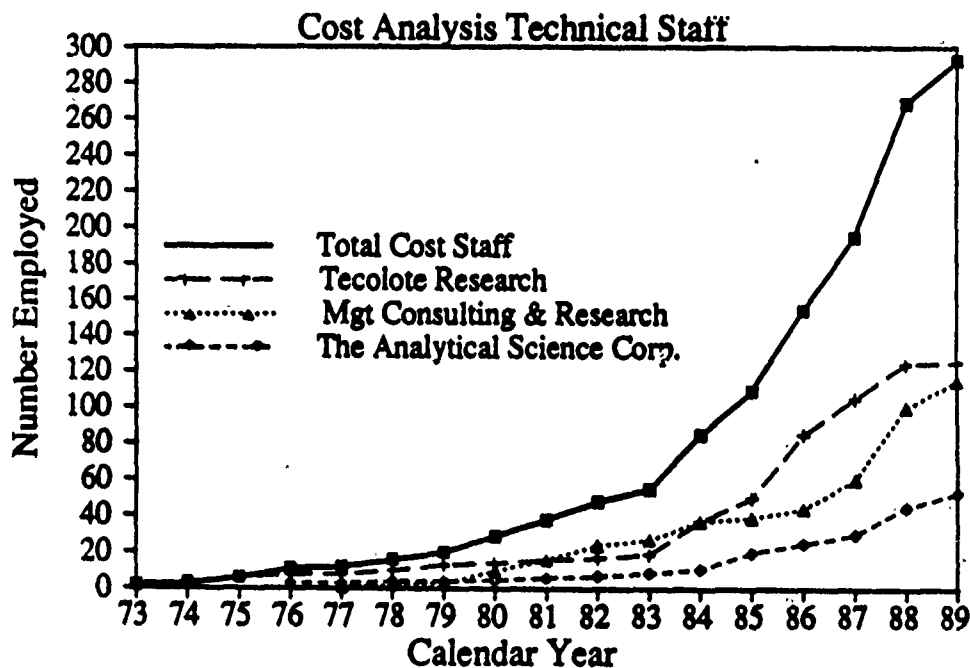


Fig. 4--Professional Service Companies

the number of new hires rose dramatically. Although not all of the cost analysts are performing purely cost-related research or defense work, the majority are; the trend supports the proposition of cost as an increasingly important component of resource allocation decisions. Moreover, indications are that recent and expected future budget constraints will contribute to further growth in the private sector. Table 3 identifies some of the significant milestones in cost analysis history. The employment trend and milestones both indicate expansion in the profession. This expansion has been necessary to meet the many challenges of the eighties. We can afford to do no less in the nineties.

Table 3
SIGNIFICANT EVENTS IN COST ANALYSIS

- 1936 - Wright formulates Cumulative Average theory of learning
- 1947 - Crawford develops Unit Cost theory of learning
- 1950 - Department of Cost Analysis founded at RAND Corporation
- 1961 - OASD Comptroller establishes Office of Systems Analysis
- 1961 - Air Force establishes cost analysis training at AFIT
- 1961 - Department of Defense institutes PPBS
- 1962 - RCA develops Programmed Review of Information for Costing and Evaluation (PRICE) as in-house estimating model
- 1962 - McNamara directs use of PERT COST as standard DoD cost and schedule control system for major weapon systems
- 1964 - OSD Directive 7041.1, *Cost & Economic Information System*
- 1964 - OSD selects AFIT as executive agent for DoD cost training
- 1965 - President Johnson implements PPBS in all federal agencies
- 1965 - Office of Systems Analysis upgraded to Assistant Secretary
- 1966 - Implementation of Army-wide cost analysis program
- 1966 - Cost Information Report (CIR) established
- 1966 - First Annual Cost Analysis Symposium, hosted by IDA
- 1966 - DoD Directive 7000.1, *Resource Management Systems*
- 1967 - DoD Directive 7000.2, *Performance Measurement for Selected Acquisitions (C/SCSC)*
- 1968 - DoD Directive 7000.3, *Selected Acquisition Reports (SAR)*
- 1969 - DoD Directive 7041.3, *Economic Analysis of Proposed Department of Defense Investments*
- 1969 - Defense Economic Analysis Council (DEAC) formed
- 1971 - DoD Directive 5000.1, *Acquisition of Major Defense Systems* (implements design-to-cost concept)
- 1972 - OASD for Program Analysis & Evaluation (formerly known as Systems Analysis)
- 1973 - DoD Directive 5000.4, *Cost Analysis Improvement Group*
- 1975 - DoD Directive 5000.28, *Design to Cost*
- 1975 - Public Law 94-106, formalized SAR reporting to Congress
- 1975 - RCA PRICE Models go on market; DoD is a major user
- 1978 - National Estimating Society founded
- 1981 - Carlucci initiatives on Weapon Systems Acquisition
- 1981 - Institute of Cost Analysis (ICA) founded
- 1981 - Professional Designation in Cost and Price Analysis
- 1982 - AFIT establishes Master's Degree in Cost Analysis
- 1983 - First edition of the *Journal of Cost Analysis and Pricing*
- 1985 - Naval Center for Cost Analysis founded
- 1985 - Army Cost and Economic Analysis Center founded
- 1985 - Packard Commission (President's Blue Ribbon Commission on Defense Management)
- 1985 - Air Force Cost Center founded; fully operational in 1987
- 1988 - Agreement between National Estimating Society and Institute for Cost Analysis to merge as National Society of Cost Analysis-- to occur no later than 1990

The Nineties--Past is Prologue .

Having reviewed some of the history of cost analysis, it is possible to draw some tentative conclusions in an attempt to establish directions for improvement in the coming decade. By and large, one might conclude that cost analysis operates under severe constraints--both internal and external. Some of the more specific lessons one might draw from the evolving role of cost analysis are:

1. Competition for scarce resources at the national level will continue to impair agreement on military requirements. Thus, full funding of service budget requests is unlikely over the long term. In turn, the demand for more accurate, detailed cost analyses will increase and the use of cost analysis will continue to move from planning to programming to budgeting, reflecting the short-term perspective of our political structure. But the use of cost analysis for budgetary purposes is considered a misuse by many, and the current state-of-the-art in cost analysis does not provide the level of precision expected by Congress and many defense critics.

2. Cost analysis has a distinct impact on development, procurement, and operational decisions. Of these three, the procurement arena will remain the most visible and challenging area, although operating costs have received greater visibility in the last 15 years. The many cost management methodologies (C/SCSC, design-to-cost, life cycle cost, *should* cost, could cost, etc.) cannot cure structural problems in the acquisition community. Likewise, the Carlucci initiatives, the Grace Commission, the Packard Commission, and countless other studies on the acquisition process will not usher us into an era of cheap, high-quality weapons. We can improve cost analysis to improve decisionmaking, but that will not alter the essentially political nature of American arms procurement. In short, cost analysis is not a panacea.

3. The data problem that existed 40 years ago is still not and probably cannot be solved (although tremendous improvements have been made). The increasing pace of technological change and greater weapons complexity will strain the limits of parametric estimates as the historical database becomes less and less relevant. While different methods vary in accuracy, it may not be possible to increase estimating precision beyond a rough order of magnitude for advanced weapons.

4. If the news media is our judge, then the defense community has failed to remove the appearance that estimates are deliberately kept low for major programs with high-level interest. Professionalism requires that cost estimates not be used as part of political-budgetary maneuvering.

5. Cost analysis is subject to considerable uncertainty. Many sources of risk beyond estimating risk combine to invalidate otherwise good analysis, but cost estimators will continue to be held accountable for the accuracy of their work.

As we move into the nineties, our goal should be to improve cost estimating by incorporating elements of total program risk. Although cost growth has declined over the years in percentage terms, due in part to improvements in the art and science of cost analysis, the public now holds the military to a higher standard of accountability. To help eliminate public cynicism and skepticism we will have to improve further. David Packard, who said in 1969 that poor cost estimating was a result of "overoptimism" and was the "largest single cause" of cost growth, believed in 1988 that the Pentagon "deliberately" underestimates cost and schedules [31]. Unfortunately, the danger in poor estimating goes beyond bruised egos and a damaged professional image. Poor estimates can lead to the improper allocation of scarce resources which directly diminish national security.

At the same time, we must also maintain sight of the proper role of cost analysis in order to provide information to key decisionmakers on the impact of resource choices. To this end, the services tend to label every splinter of estimating, pricing, and cost management as cost analysis. Although cost analysis can be narrowly defined, it is still all of these and more. It encompasses the complete exploration of the full resource requirements for a given system or force structure. But the highest and best use of cost analysis remains when it is employed as "a basis for choosing between ideas worthwhile to put into research and development" [32]. The choice of weapons, however, depends on far more than expected costs or even cost effectiveness. More often than not, Congressional and service politics, industry pressures, military strategy, perceptions of the threat, and the desire and necessity for superior technology outweigh cost considerations. Thus, as we work to improve our own abilities in cost analysis, and to improve decision-making in the development, production, and operation of our force structure, we must also be fully cognizant of the limitations of our field.

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APPENDIX A FROM SYSTEMS ANALYSIS TO POLICY ANALYSIS

While the role of systems analysis was diminished within DoD in the early seventies, the evolution of systems analysis as a significant methodological tool continued at RAND and elsewhere. Systems analysis was important because it established a framework for problem solution. As time passed, this framework became more sophisticated in its ability to consider effects that were previously treated as externalities. The greater context in which problems were considered became known as policy analysis. Political, sociological, organizational, and other factors that were once givens could now be treated as variables. Policy analysis, according to Gene Fisher of The RAND Corporation, expanded "the boundaries of the problem space."

Policy analysis also places greater demands on cost analysts. No longer could the analyst exclusively rely on dollar cost as a measure of real economic costs. Consideration of non-economic costs and their distribution is also necessary to fully evaluate a proposed policy and its implementation strategy. For example, military issues ranging from base closings to the basing of new nuclear weapons require consideration of more than dollar cost savings and outlays. Base closings represent lost future opportunities for military use and impose economic and non-economic costs on small segments of society. The military has also learned, in the case of basing strategies for nuclear weapons, that aggregate cost benefit equations will not sell proposed policy if distributional effects are deemed too great on certain groups. Military cost analysts working at the higher policymaking levels will have to broaden their horizons to properly address these issues. For an introduction to this topic, the reader is referred to Gene Fisher's "Cost Considerations in Policy Analysis," *Policy Analysis*, Winter 1977, pp. 107-114.